

Sarah Wheeler Keenan, Ph.D.

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Research Interests

My research interests relate broadly to paleobiology, environmental geochemistry, and biogeochemical processes occurring on earth's surface. I am particularly interested in the interactions between life (vertebrate and microbial) and earth systems in the modern and geologic past, as well as soil biogeochemistry, stable C and N isotopes, biogeochemical cycling of nutrients during animal decomposition, and microbial ecology. Additional research interests include symbiotic associations between micro- and macro-fauna in surface and subsurface systems, and modern and fossil bone geochemistry.

Education

- University of Tennessee**, Knoxville, Tennessee, USA. **Ph.D.—Geology** *May 2014*
Academic Advisor: Dr. Annette S. Engel
Dissertation Title: Gastrointestinal microbial diversity and diagenetic alteration of bone from the American alligator (*Alligator mississippiensis*)
Areas of Emphasis: Geochemistry, Geomicrobiology, and Geobiology
- University of Bristol**, Bristol, United Kingdom. **MSc—Palaeobiology** *September 2009*
Academic Advisors: Dr. Michael J. Benton and Dr. Clive N. Trueman
Thesis Title: Rare earth elements and rates of fossilization in tetrapod bone
Areas of Emphasis: Palaeobiology, Taphonomy, Geochemistry
- University of St. Andrews**, St. Andrews, Fife, Scotland. **BSc—Geoscience and Environmental Biology** *June 2008*
Undergraduate Advisor: Dr. Anthony R. Prave
Thesis Title: Taphonomy of *Triceratops* from the Upper Hell Creek Formation, Garfield Co., MT
Areas of Emphasis: Sedimentology, Earth System Processes

Professional Experience

South Dakota School of Mines and Technology, Dept. of Geology and Geological Engineering

Assistant Professor in Paleontology *August 2018 to present*

Courses taught:

- *Quantitative Methods in Paleontology* (GEOL 773, 3 credits, Graduate-level elective course; Fall-even)
- *Paleoenvironments* (GEOL 774, 2 credits; Graduate-level elective course, Spring-odd)
- *Aqueous Geochemistry* (GEOL 421/521, 3 credits; Undergraduate/Graduate-level course, required for Geology Majors, Fall)
- *Introduction to Geology, Geological Engineering, and Mining Engineering* (GEOL/GEOE/MEM 110L, 1 credit; Required for Majors, Fall)
- *Geomicrobiology* (GEOL 435/535, 3 credits; Undergraduate/Graduate-level elective course, Spring-even)
- *Graduate seminars* (GEOL 790, 1 credit; Graduate-level course, various topics in paleontology and geology, Spring-odd)

- *Physical Geology* (GEOL 201 and 201L, 4 credits; Required for majors, gen-ed.)

University of Tennessee, Dept. of Biosystems Engineering and Soil Science

Postdoctoral Research Associate

February 2016 - June 2018

- **Responsibilities:** Conduct research related to vertebrate decomposition and biogeochemical cycling associated with nutrient “hotspots” as part of an NSF-funded grant. Specific goals of the project include: (A) Evaluating the fate and transport of nitrogen species in soil during decomposition; (B) Assessing microbial community dynamics during decomposition; (C) Integrating biogeochemical cycling with changes in microbial communities.
- **Additional projects:** Collaborative project with forensic anthropologists at UTK characterizing the *microbial communities of skeletonized human bones* (surface and subsurface burials) and linking community structure with bone properties (i.e. chemical composition, microstructure)
 - *Soil biogeochemistry of a human mass grave*
 - *Nematode population shifts during vertebrate decay*
 - *Whole-skeleton bone geochemistry and collagenase activity*

Saint Louis University, Dept. of Biology

Postdoctoral Research Associate

June 2014 - January 2016

- **Responsibilities:** Conduct research as part of an NSF-funded grant evaluating the response of the western painted turtle to anoxia. My responsibilities include: (1) Collection and extraction of RNA for transcriptomic sequencing; (2) Bioinformatics and data processing of RNA-derived data; (3) Develop and conduct research related to turtle bone geochemistry; (4) Mentor undergraduate and graduate students; (5) Take part in outreach with local high school students through field and lab-based research.
- **Courses taught:** Designed and taught a graduate student seminar entitled, “*Geobiology and the evolution of our modern Earth system*,” in the Department of Biology

University of Tennessee, Dept. of Earth and Planetary Sciences

Graduate Teaching Assistant

August 2011 - May 2014

- Geology 102—Earth, Life, and Time (introductory course)
- Geology 103—Earth’s Environments (introductory course)
- Geology 340—Sedimentology and Stratigraphy (upper-level course; two different semesters with different instructors)
- Geology 320—Paleobiology (upper-level course)
- Geology 460/560—Principles of Geochemistry (upper-level and graduate course)

Instructor

Summer session 2013

- **Responsibilities:** Instructor for Geology 102—Earth, Life, and Time (introductory course); included making lectures, tests, homework, labs.

UTK Geology Club, Vice President (May 2012-May 2013)

Louisiana State University, Dept. of Geology and Geophysics

Research Assistant

August 2009 - June 2011

- **Responsibilities:** Conducting independent research towards my Ph.D. including sample collection, processing, data acquisition and analysis

Field Research Experience

Museum of the Rockies (MOR), Montana State University, *summers of 2007-2011*

Activities and Responsibilities:

- 2010 and 2011: Continued field research with the MOR, conducting a taphonomic survey of dinosaur sites.
- 2009: Senior crew member involved in independent field research towards my master's thesis, finding and collecting fossil material, and training new crew members.
- 2008: Senior crew member responsible for collecting field data for sites, fossil collection, prospecting for new sites, and educating new crew members in the basics of field paleontology and sedimentology.
- 2007: Conducted field research, and collected taphonomic and geologic data for the MOR as part of my undergraduate thesis based in the Hell Creek of eastern MT.

Ph.D. Field Work (2009-2014)

- Alligator collection and necropsy across the southeast including Louisiana, Mississippi, Arkansas, Florida, South Carolina with various federal agencies.
- *Rockefeller Wildlife Refuge, Louisiana*: Sampling soil and water for geochemical characterization, including P speciation; characterizing sediment, vegetation, and bone microbial communities over the course of decomposition

Postdoctoral Field Work (February 2016-2018)

- Establish and monitor vertebrate decomposition experiments in Oak Ridge, Tennessee. Responsible for experimental design and set up, day-to-day data and sample collection (soil and gas), sample processing, and data management.

Postdoctoral Field Work (June 2014- January 2016)

- Trap and collect western painted turtles from field areas in Illinois and Missouri for two projects: *Primary*: NSF-funded project evaluating gene expression profiles in normoxic and anoxic turtles; *Secondary*: Internal grant from SLU (Beaumont Grant) funding a comparative assessment of bone geochemistry in northern and southern painted turtle populations.

Selected Additional Field Work (2009-present)

- *Dauphin Island, Alabama (2012)*: BP Deep Water Horizon oil spill sampling, including water geochemistry, sediment for microbial characterization, and molluscs for contaminant assessment.
- *Caves of Tennessee (2013-2018)*: Associate investigator for biotic inventories of cave vertebrate and invertebrate fauna in East Tennessee.
- *Biodegradable Mulch Project (2016-2018)*: Assist with bi-annual field sampling of soils for a project evaluating microbial degradation of agricultural plastics.
- *Nutrient hotspots in South Dakota (2018-present)*: Animal decomposition experiments based in prairie ecosystems, SD

Peer-reviewed publications

^{UG}Undergraduate Student; ^{GS}Graduate Student

Google Scholar: Citations (244), h-index (7), i10-index (7).

20. Emmons, A.L.^{GS}, Mundroff, A.Z., **Keenan, S.W.**, Davoren, J., Andronowski, J., Carter, D. O., and DeBruyn, J.M. (2020). Characterizing the postmortem human bone microbiome from surface decomposed remains. *PLoS One*, 15:e0218636, DOI:10.1371/journal.pone.0218636.
19. Fanter, C.E.^{GS}, Lin, Z., **Keenan, S.W.**, Janzen, F.J., Mitchell, T.S., and Warren, D.E. (2020). Development-specific transcriptomic profiling suggests new mechanisms for anoxic survival in the ventricle of overwintering turtles. *Journal of Experimental Biology*, 223, DOI: 10.1242/jeb.213918.
18. **Keenan, S.W.**, Schaeffer, S. M., and DeBruyn, J.M. (2019). Spatial changes in soil stable isotopic composition in response to carrion decomposition. *Biogeosciences*, DOI: 10.5194/bg-16-3929-2019.
17. **Keenan, S.W.** and DeBruyn, J. M. (2019). Changes to vertebrate tissue stable isotope ($\delta^{15}\text{N}$) composition during decomposition. *Scientific Reports*, 9:9929, DOI: 10.1038/s41598-019-46368-5.
16. **Keenan, S.W.**, Pasteris, J.D., Wang, A., and Warren, D.E. (2019). Heterogeneous bioapatite carbonation in western painted turtles is unchanged after anoxia. *Comparative Biochemistry and Physiology, Part A*, 233: 74-83.
15. **Keenan, S.W.**, Emmons, A.L.^{GS}, Taylor, L.S.^{GS}, Phillips, G., Mason, A.R.^{GS}, Mundorff, A., Bernard, E.C., Davoren, J., and DeBruyn, J.M. (2018). Spatial impacts of a multi-individual grave on microbial and microfaunal communities and soil biogeochemistry. *PLoS One*, DOI: 10.1371/journal.pone.0208845.
14. Odegard, D.T.^{GS}, Sonnenfelt, M.A.^{UG}, Bledsoe, J.G., **Keenan, S.W.**, Hill, C.A., and Warren, D.E. (2018). Changes in the material properties of the shell during simulated aquatic hibernation in the anoxia-tolerant painted turtle. *Journal of Experimental Biology*, <https://doi.org/10.1242/jeb.176990>.
13. **Keenan, S.W.**, Schaeffer, S.M., Jin, V.L., and DeBruyn, J.M. (2018). Mortality hotspots: nitrogen cycling in forest soils during vertebrate decomposition. *Soil Biology and Biochemistry*, 121: 165-176.
12. **Keenan, S.W.**, Widga, C., DeBruyn, J.M., and Schaeffer, S.M. (2018). Nutrient hotspots through time: a field guide to modern and fossil taphonomy in East Tennessee in Engel, A.S. and Hatcher, B., eds., Field Guide 50: 2018 Southeastern Section Meeting Field Guide, pp. 61-74.
11. **Keenan, S.W.** and Engel, A.S. (2017). Reconstructing diagenetic conditions of bone at the Gray Fossil Site, Tennessee, USA. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 471: 48-57.
10. **Keenan, S.W.** and Engel, A.S. (2017). Early diagenesis and recrystallization of bone. *Geochimica et Cosmochimica Acta*, 196: 209-223.
9. **Keenan, S.W.** and Tellez, M. (2016). *Trachemys scripta elegans* (Red-eared slider) and *Chrysemys picta bellii* (Western painted turtle). Endoparasites. *Herpetological Review*, 47(3): 451-453.
8. **Keenan, S.W.** (2016). From bone to fossil: a review of the diagenesis of bioapatite. *American Mineralogist*, 101: 1943-1951.
7. **Keenan, S.W.**, Engel, A.S., Roy, A., and Bovenkamp-Langlois, G.L. (2015). Evaluating the consequences of diagenesis and fossilization on bioapatite lattice structure and composition. *Chemical Geology*, 413: 18-27.

6. **Keenan, S.W.**, Hill, C.A.^{GS}, Kandoth, C., Buck, L.T., and Warren, D.E. (2015). Transcriptomic response of the western painted turtle heart and telencephalon to anoxia. *PLoS One*, DOI: 10.1371/journal.pone.0131669.
5. **Keenan, S.W.** and Elsey, R.M. (2015). The good, the bad, and the unknown: microbial symbioses of the American alligator. *Integrative and Comparative Biology*, DOI: 10.1093/icb/icv006.
4. **Keenan, S.W.**, Niemiller, M.L., and Williams, B.W. (2014). Observations of *Cambarus bartonii cavatus* (Decapoda: Cambaridae) and ectosymbiotic branchiobdellidans (Annelida: Clitellata) in Cruze Cave, Knox County, Tennessee, USA. *Speleobiology Notes*, 6: 55-61.
3. **Keenan, S.W.** and Ellwood, B.B. (2014) Geophysical evaluation of the Richland and Holloway Mounds, southeastern Louisiana, U.S.A. *Geoarchaeology*, 29: 312-325.
2. **Keenan, S.W.** and Scannella, J.B. (2014). Paleobiological implications of a *Triceratops* bonebed from the Hell Creek Formation, Garfield County, northeastern Montana. In (Wilson, G.P., Clemens, W.A., Horner, J.R., and Hartman, J.H., eds.) Through the end of the Cretaceous in the type locality of the Hell Creek Formation in Montana and adjacent areas. Geological Society of America Special Paper 503. Pp.349-364.
1. **Keenan, S.W.**, Engel, A.S. and Elsey, R.M. (2013). The alligator gut microbiome and implications for archosaur symbioses. *Scientific Reports*, DOI: 10.1038/srep02877.

Book Chapters

2. **Keenan, S.W.** (2019) Fossilization. Encyclopedia of Geology. Elsevier (*in press*).
1. **Keenan, S.W.** (2013) Freshwater vertebrate animal metagenomics, Alligatorinae. In (Nelson, K., ed.) Encyclopaedia of Metagenomics. Springer, DOI: 10.1007/978-1-4614-6418-1_101-8.

Manuscripts Submitted and In Preparation

- Keenan, S.W.** and Tellez, M. Symbiotic associations in crocodylians: present, past, and future. Ed. Ballard, H.W. and Farlow, J. Indiana Press volume on crocodylian biology and paleobiology (*in progress*).
- Gladstone, N.S.^{GS}, Pieper, E.B., **Keenan, S.W.**, Paterson, A.T., Slay, M., Dooley, K., Engel, A.S., Niemiller, M.L. A large range extension of the Blue Ridge Springsnail, *Fontigens orolibas*, Hubricht, 1957 (Gastropoda: Emmericiidae) and its conservation implications. Freshwater Mollusk Biology and Conservation (*in review*).
- Keenan, S.W.** and DeBruyn, J.M. The Paleontology of Gnash: From Fossils to Fangdom. UTK Extension Module (*in preparation*).
- Emmons, A.L., DeBruyn, J.M., Davoren, J., Carter, D., **Keenan, S.W.**, and Mundorff, A.Z. The postmortem bone microbiome: implications of rDNA survivability in buried remains. Microbiome (*in preparation*).
- Keenan, S.W.** Thermodynamic modelling of apatite stabilities in a wetland and fluvial system: implications for bioapatite diagenesis. Chemical Geology (*in preparation*).
- Keenan, S.W.** and Engel, A.S. Soil microbial community composition of a wetland marsh: implications for bone preservation. Frontiers in Microbiology (*in preparation*).

Abstracts

2020:

- DeVault, G.A.^{GS} and **Keenan, S.W.** Using tooth wear and decomposition to interpret geochemistry in paleontological localities. *Geological Society of America* (poster, online).

Keenan, S.W. and DeBruyn, J.M. Surface and subsurface vertebrate decomposition result in protracted soil nitrogen stable isotopic enrichment. *Rocky Mountain Section of the Geological Society of America*, Provo, Utah (May; oral presentation, cancelled due to COVID-19).

Cyrier, M.*^{UG}, Chase, K., and **Keenan, S.W.** Impacts of seasonality on subsurface conditions in Rushmore Cave, South Dakota. *Rocky Mountain Geobiology*, Golden, CO (April; *presenter, cancelled due to COVID-19).

2019:

Keenan, S.W. and DeBruyn, J. M. Quantifying the long-term impacts of animal decomposition on soil biogeochemical cycling. *Geological Society of America*, Phoenix, AZ (poster presentation).

Keenan, S.W. + Temporal and spatial dynamics of animal decomposition in terrestrial systems. *Geobiology Symposium*, Banff, Canada (+invited oral presentation).

Driebergen, J.*^{GS}, **Keenan, S.W.** Cosmopolitan anuran assemblages: proxies for the effects of climate change? *Society of Vertebrate Paleontology*, Brisbane, Australia (*presenter).

Emmons, A.L.*^{GS}, **Keenan, S.W.**, Davoren, J., DeBruyn, J.M., Carter, D., and Mundorff, A.Z. DNA preservation in bone in a multi-individual burial. *Proceedings of the American Academy of Forensic Sciences*, Baltimore, MD (*presenter).

Mason, A.R.*^{GS}, **Keenan, S.W.**, Emmons, A.L.^{GS}, Taylor, L.S.^{GS}, Phillips, G., Mundorff, A.Z., Bernard, E.C., and DeBruyn, J.M. Spatial impact of a multi-individual grave on soil biochemistry and microbial ecology. *Soil Science Society of America*, San Diego, CA (*presenter).

2018:

Keenan, S.W. and DeBruyn, J.M. Spatial and temporal soil responses to carrion decay. *Goldschmidt*, Boston, MA (poster presentation).

Emmons, A.L.*^{GS}, **Keenan, S.W.**, Mason, A.^{GS}, Höland, K., Campagna, S., Davoren, J., DeBruyn, J.M, Mundorff, A. Edaphic and biogenic influences of skeletal DNA degradation in a multi-individual grave. *International Society for Microbial Ecology*, Leipzig, Germany (*presenter).

Mason, A.R.^{GS*}, **Keenan, S.W.**, Emmons, A.L.^{GS}, Taylor, L.S.^{GS}, Phillips, G., Mundorff, A.Z., Bernard, E.C., and DeBruyn, J.M. Spatial impact of a multi-individual grave on soil biochemistry and microbial ecology. *American Society for Microbiology*, Atlanta, GA (*presenter; winner of the ASM outstanding abstract award).

Grimes, E.^{UG*}, **Keenan, S.W.**, and DeBruyn, J.M. The enzymatic and geochemical composition of bone. *Undergraduate Research Symposium and EUREKA (Exhibition of Undergraduate Research and Creative Achievements)*, University of Tennessee (*oral and poster presentations).

Keenan, S.W. and DeBruyn, J.M. Temperature and microbial effects on nitrogen cycling at simulated mortality decomposition hotspots. *Southeastern Geological Society of America*, Knoxville, TN (oral presentation).

Keenan, S.W., Widga, C., and DeBruyn, J.M. Reconstructing nutrient hotspots in time: insights from the Gray Fossil Site, Tennessee. *Southeastern Geological Society of America*, Knoxville, TN (oral presentation).

Emmons, A.L.*^{GS}, **Keenan, S.W.**, Taylor, L.S.^{GS}, Davoren, J., DeBruyn, J.M., Phillips, G., Bernard, E.C., and Mundorff, A.Z. Microbial ecology and soil geochemistry in a multi-

individual grave. *Proceedings of the American Academy of Forensic Sciences*, Seattle, WA (*presenter).

2017:

Keenan, S.W., Schaeffer, S.M, Jin, V.L., and DeBruyn, J.M. Soil biogeochemical cycling and isotope dynamics during vertebrate decomposition. *Soil Science Society of America*, Tampa, FL (oral presentation).

Taylor, L.S.*^{GS}, Phillips, G., **Keenan, S.W.**, Bernard, E.C., and DeBruyn, J.M. Nematode community succession in vertebrate carcass decomposition soil hot spots. *Soil Science Society of America*, Tampa, FL (*presenter).

Keenan, S.W., Schaeffer, S.M., and DeBruyn, J.M. Stable isotope dynamics of vertebrate tissues during decomposition. *International Society for Environmental Biogeochemistry*, Cairns, Australia (oral presentation).

Bernard, E.C.*^{GS}, Phillips, G., Taylor, L.S.*^{GS}, **Keenan, S.W.**, and DeBruyn, J.M. Nematode assemblages and succession on and under beaver carcasses. *Society of Nematologists*, Williamsburg, VA (*presenter).

Taylor, L.S.*^{GS}, Phillips, G., **Keenan, S.W.**, Bernard, E.C., and DeBruyn, J.M. Spatial nematode community distributions associated with human decomposition in a mass grave. *Society of Nematologists*, Williamsburg, VA (*presenter).

Engel, A.S.*^{GS}, Niemiller, M.L., Zigler, K.S., Stephen, C.D.R.*^{GS}, Carter, E.T.*^{GS}, Paterson, A.T., **Keenan, S.W.**, and Taylor, S.J. Invertebrate and vertebrate cave fauna records for the Appalachian Valley and Ridge. *Proceedings of the 17th International Congress of Speleology*, Sydney, Australia, pp. 82-86 (*presenter).

Keenan, S.W., Paterson, A.T., Niemiller, M.L., Slay, M.E., Clark, S.A., and Engel, A.S.*^{GS}. Observations of the first stygobiont snail (Hydrobiidae, *Fontigens* sp.) in Tennessee. *Proceedings of the 17th International Congress of Speleology*, Sydney, Australia, pp. 91-94 (*presenter).

Keenan, S.W., Schaeffer, S.M., Jin, V.L., and DeBruyn, J.M. Biogeochemistry of vertebrate decomposition in a forest ecosystem. *Southeastern Biogeochemistry Symposium*, Athens, GA.

Emmons, A.L.*^{GS}, **Keenan, S.W.**, Mundorff, A., Davoren, J., and DeBruyn, J.M. Skeletal DNA preservation and bone-associated microbes: the implications for DNA sampling strategies in forensic identification. *Proceedings of the American Academy of Forensic Sciences*, New Orleans, LA, p. 108-109 (*presenter).

2016:

DeBruyn, J.M.*^{GS}, Cobaugh, K.L., Moats, M., Stevens, J.D., and **Keenan, S.W.** Postmortem hot spots: soil microbial community succession below decomposing vertebrate mortalities. *Soil Science Society of America*, Phoenix, AZ (*presenter).

Keenan, S.W., Hauther, K.A.*^{GS}, and DeBruyn, J.M. Soil responses to a nutrient “hotspot”: the biogeochemistry of vertebrate decomposition in a forest ecosystem. *Midwest Geobiology*, Cincinnati, OH (oral presentation).

Keenan S.W., Emmons, A.L.*^{GS}, Mundorff, A., Davoren, J.M., and DeBruyn, J.M. Bone-associated microbes: implications for the long-term stability of bone in terrestrial systems. *Geological Society of America*, Denver, CO (oral presentation).

Engel, A.S.*^{GS}, Paterson, A.T., and **Keenan, S.W.** A little drop will do: surprises from epikarstic drip water microbiology. *National Speleological Society Convention*, Ely, NV (*presenter).

Keenan, S.W., Paterson, A.T., Niemiller, M.L., Slay, M.E., and Engel, A.S. The first record of a stygobiontic cave snail (Hydrobiidae) from Tennessee. *National Speleological Society Convention*, Ely, NV (oral presentation).

2015:

Keenan, S.W., and Engel, A.S. Thermodynamic predictions of bioapatite stability in environmental systems. *GSA Abstracts with Programs*, 47(7):461, session no. 180, Baltimore, MD (oral presentation).

Keenan, S.W., Pasteris, J.D., Wang, A., and Warren, D.E. A mineralogical perspective on a physiological problem: bioapatite carbonation in the western painted turtle. *Midwest Geobiology Symposium*, Bloomington, IN (oral presentation).

Engel, A.S.*^{UG}, Harmon, D.^{UG}, Paterson, A.T., and **Keenan, S.W.** Cave dripwater microbiology reveals epikarstic biogeochemical cycling that can affect speleothem records. *International Society of Environmental Biogeochemistry*, Slovenia (*presenter).

Keenan, S.W.⁺, Pasteris, J.D., Wang, A., and Warren, D.E. Mineralogical contributions to overwintering survival in the western painted turtle. *St. Louis Ecology, Evolution, and Conservation*, St. Louis, MO (+invited oral presentation).

Keenan, S.W.⁺, Elsey, R.M., and Engel, A.S. The good, the bad, and the unknown: microbial symbioses of the American alligator. *Society for Integrative and Comparative Biology*, West Palm Beach, FL (+invited oral presentation).

2014:

Keenan, S.W., and Taylor, L.A. The use of apatite as an archive of processes in Man and the Moon. *GSA Abstracts with Programs*, 46(6):26, session no. 1, Vancouver, Canada (Pardee Session oral presentation).

Keenan, S.W.⁺, Engel, A.S., Roy, A., and Bovenkamp, G.L. From bone to fossil: early diagenesis of apatite. *Goldschmidt*, Sacramento, CA (+invited oral presentation).

2013:

Keenan, S.W., and Engel, A.S. Visualizing the early diagenesis of bone. *Midwest Geobiology Symposium*, Indianapolis, IN (oral presentation).

Harmon, D.R.*^{UG}, Brannen, K.M., **Keenan, S.W.**, and Engel, A.S. Physical and geochemical controls on cave dripwater microbial diversity. *Midwest Geobiology Symposium*, Indianapolis, IN (*presenter).

Keenan, S.W., and Engel, A.S. Assessing fossil bone depositional environment from structural and compositional changes. *GSA Abstracts with Programs*, 45(7):695, session no. 300, Denver, CO (oral presentation).

Harmon, D.R.*^{UG}, Brannen, K.M., **Keenan, S.W.**, and Engel, A.S. Drip water chemistry from the Cascade Cave system, Kentucky, and implications for epikarst-derived microbial communities. *GSA Abstract with Programs*, 45(7):778, session no. 341, Denver, CO (*presenter).

Keenan, S.W., and Engel, A.S. Geochemical analysis of *Alligator* sp. bone from the Gray Fossil Paleosinkhole Site, Tennessee. *National Speleological Society Convention*, Shippensburg, PA (oral presentation).

2012:

Keenan, S.W., Engel, A.S., and Elsey, R.M. Bacterial community diversity of the American alligator gastrointestinal tract. *ISS Abstracts*, Krakow, Poland (oral presentation).

2011:

- Keenan, S.W.**, and Engel, A.S. Hydroxyapatite stability in wetland soils and the implications for bone preservation. *ISEB Abstracts*, Istanbul, Turkey.
- 2010:
- Keenan, S.W.**, and Engel, A.S. Inferring ancestral Crocodylomorpha-microbe symbioses based on the American alligator (*Alligator mississippiensis*) gut microbiome. *GSA Abstracts with Programs*, 42(5):89, session no. 29, Denver, CO.
- Keenan, S.W.**, Ellwood, B.B., and Mann, R. Indian mounds in Louisiana: applications of magnetic susceptibility and electrical resistivity to geoarchaeology. *GSA Abstracts with Programs*, 42(5):28, session no. 3, Denver, CO (oral presentation).
- Hall, L.E.^{UG}, and **Keenan, S.W.** Taphonomy of a new *Tyrannosaurus rex* specimen from the Hell Creek Formation, Montana, *JVP Abstracts*, 30(3):100A, session III, Pittsburgh, PA.
- Keenan, S.W.**, and Engel, A.S. The gastrointestinal flora of wild and farm-raised American alligators (*Alligator mississippiensis*), *CSG Program and Abstracts*, p.100, Manaus, Brazil.
- Keenan, S.W.**, and Engel, A.S. Pyrosequencing of 16S ribosomal RNA from the gastrointestinal microbiome of wintering wild and farmed American alligators (*Alligator mississippiensis*), *ISME 10*, PS.25.029, Seattle, WA.
- 2009:
- Keenan, S.W.** + Taphonomy of a *Triceratops* bonebed from the Upper Hell Creek Formation, Garfield County, Montana, *NAPC Abstracts*, 3:148, session S6, Cincinnati, OH (+invited oral presentation).
- Keenan, S.W.**, Trueman, C.N., and Benton, M.J. Rare earth elements and rates of fossilization in vertebrate bone, *SVP, JVP Abstracts*, 29(3):125A, technical session IX, Bristol, England.
- Keenan, S.W.**, Trueman, C.N., and Benton, M.J. Rare earth elements and rates of fossilization in tetrapod bone, *GSA Abstracts with Programs*, 41(7):628, Portland, OR.
- 2008:
- Keenan, S.W.**^{UG} Taphonomy of a *Triceratops* bonebed from the Upper Hell Creek Formation, Garfield County, Montana. *JVP Abstracts*, 28(Suppl. to 3):99A, Cleveland, OH.

Invited Talks and Symposia

- 2019: Geobiology Society Conference, Banff, Alberta, Canada.
- 2019: Paha Sapa Grotto, Rapid City, SD.
- 2019: Darton Geological Society, Rapid City, SD.
- 2018: South Dakota School of Mines & Technology, Department of Geology and Geological Engineering, Rapid City, SD.
- 2017: Nashville Grotto, Nashville, TN.
- 2016: Tennessee Cave Survey Spring meeting, Knoxville, TN.
- 2015: Stephen F. Austin State University, Department of Geology.
- 2015: St. Louis Ecology, Evolution and Conservation (SLEEC), St. Louis, MO.
- 2015: The Society for Integrative and Comparative Biology (SICB), in a special session on the “*Integrative Biology of the Crocodilia*,” West Palm Beach, FL.
- 2014: Saint Louis University, Department of Biology.
- 2014: Goldschmidt in a session focused on apatite geochemistry, Sacramento, CA.
- 2013: East Tennessee Geological Society, Oak Ridge, TN.
- 2012: University of Cambridge, UK, Department of Zoology.
- 2011: The Baton Rouge Chapter of the Archaeological Society of Louisiana.
- 2009: The North American Paleontological Convention (NAPC), Cincinnati, OH, in a symposium on the Hell Creek Formation, Montana.

Awards, Fellowships, and Grants

Awards

- ASA, CSSA, SSSA *Excellence in Advocacy Award* (2018), all expenses paid trip to participate in the 2018 Congressional Visit Day in Washington, D.C.
- UTK, Geology Colloquium *First Place in Professional Presentations* (2013), \$200
- UTK, Dept. of Earth and Planetary Sciences, *Interdisciplinary Research Award*, (2012), \$400
- LSU Sigma Xi Grant-in-aid *Behre Scientific Writing Prize* (2010), \$125
- LSU Geology Department Rock Star *Lagniappe Poster Competition* (2nd place, 2010), \$200

Fellowship and Research Assistantships

- Gulf of Mexico Research Initiative (GoMRI, funded by NSF and BP; 2012): \$1,500 stipend to assist with sample collection and processing post Deep Water Horizon.
- Marathon Oil Corporation Geoscience Diversity (GeoDE) Graduate Fellowship (2009-2011): \$30,000 per year for two years, plus \$10,000 per year for research

Research Grants

- Beaumont Faculty Development Award (with PI Dr. Daniel Warren) (2015-16) \$5,000
- Geological Society of America Student Research Grant (Ph.D., 2011) \$3,900
- Geological Society of America Student Research Grant (M.S., 2008) \$2,300
- Farouk El-Baz Student Research Grant (M.S., 2008) \$2,500

Travel Grants

- UTK Institute of Agriculture and Research Travel Grant (2016, 2018) \$2,500 (to present at GSA, Denver, CO and Goldschmidt, Boston, MA)
- UTK Dept. of Earth & Planetary Sciences Travel Award (2013) \$200 (to present research at Midwest Geobiology Symposium, Indianapolis, IN)
- UTK Dept. of Earth & Planetary Sciences Travel Award (2013) \$400 (to present research at GSA, Denver, CO)
- UTK Dept. of Earth & Planetary Sciences Travel Award (2013) \$400 (to present research at the National Speleological Society Convention, Shippensburg, PA)
- UTK Dept. of Earth & Planetary Sciences Travel Award (2013) \$200 (to participate in a workshop on Planning for a Career in Academic Geosciences, Boulder, CO)
- UTK Graduate Student Travel Fund (2013) \$250 (to participate in Cutting Edge workshop, Preparing for an Academic Career in the Geosciences, Boulder, CO)
- UTK Dept. of Earth & Planetary Sciences Travel Award (2012) \$500 (to participate in Microbe-Mineral Interactions Workshop, Cancun, Mexico)
- UTK Dept. of Earth & Planetary Sciences Travel Award (2012) \$500 (to present research at the Congress of the International Symbiosis Society, Krakow, Poland)
- The International Symposium on Environmental Biogeochemistry (ISEB, 2011) student travel award \$400 (to present research at ISEB, Istanbul, Turkey)
- UTK Graduate Student Travel Fund (2011) \$500 (to present research at ISEB)
- UTK Dept. of Earth & Planetary Sciences Travel Award (2011) \$400 (to present research at ISEB)
- LSU Department of Geology, Baker Hughes Travel Award (2010) \$400 (to present at the Crocodile Specialist Group (CSG) meeting in Manaus, Brazil)
- International Society for Microbial Ecology (ISME) student travel grant (2010) \$240 (to present at ISME in Seattle, Washington)

- University of Bristol Alumni Fund (2009) £400 (to attend NAPC)
- NAPC Student Travel Fund (2009) \$250 (to attend the North American Paleontological Convention, Cincinnati, Ohio)
- Jackson School of Geosciences Travel Grant (2008) \$500 (to attend SVP in Cleveland, Ohio)

Departmental Service and Outreach

2019:

- STEAM Café Presentation, “*Life after death: ecological impacts of animal decomposition*” and SD Public Broadcasting radio interview
- Filmed for part of a PBS documentary, *Prehistoric Road Trip* (released June 2020)
- Judge, SDMST Student Research Symposium

2017:

- Panel member at the Nashville Predators (NHL) “STEM Night” outreach event at Bridgestone Arena for ~600, K-12 students from Tennessee and Kentucky

2016-2017:

- Assisted teaching a module on soil science in forensics at “*Fun with Forensics: Adventures in Chemistry*,” a summer course for 6-8th graders.

2014-2016:

- Outreach with local high school student from the St. Louis area in collaboration with the St. Louis Zoo ZooALIVE program. As part of the outreach, I am involved in training students how to formulate basic scientific questions and conduct research. There is also a field-based component, training the students how to trap and ID turtles in the wild.

2014:

- Designed new exhibit at the McClung Museum, UTK presenting my dissertation research and results using museum specimens in a display titled, ‘How are fossils formed? Understanding the early stages of bone fossil formation.’

2012-2014:

- Volunteer at the McClung Museum of Natural History, UTK giving tours to visiting schools from the region

2012-2013:

- GeoClub Vice President, UTK
- Ph.D. student-faculty representative for Stable Isotope Faculty search

2010-2011:

- GeoClub Outreach and undergraduate tutoring, LSU and UTK
- Ph.D. student-faculty representative (LSU)

2010:

- GeoClub Outreach events:
 - Rockin’ The Swamp—Geology education event held at the Bluebonnet Swamp, Baton Rouge
 - Tutoring introductory geology undergraduate students
- Junior Regional Science Fair judge (Winter and Spring)
- GeoDE graduate student recruitment

2009:

- Science and Nature Festival: volunteer with University of Bristol Geology and Biology Departments with education and outreach

2004-2008:

- Science Week Outreach: geology and paleontology education for middle and high school students from Fife, Scotland (University of St. Andrews)

Student Mentoring at SDSMT

Undergraduate Students

2019-2020:

- Michael Cyrier
 - Planned to present research at Rocky Mountain Geobiology Symposium
 - Received a research grant from the Geological Society of America, Rocky Mountain Section
- Zakary Jewell

2018-2019:

- Seth Vandenberg, *Taphonomy of vertebrate fossils from the Pierre Shale, SD*
 - Received 2nd place in the SDSMT Student Research Symposium poster competition

Graduate Student Advising

Current

Grace DeVault (MS Paleontology, Aug. 2019-present): geochemistry of the Pig Dig Site, Badlands NP

Graduate Students: Committee Member

Current

Brooke Long (PhD, 2018-present); Patrick Wilson (PhD, 2018-present); Madigan Cochran-Bjerke (MS, Aug. 2018-present); Brian Lauters (MS, Aug. 2018-present); Gavin Davidson (MS, Sept. 2019-present).

Graduated

Shannon Harrel (MS, Aug. 2018-Dec. 2019)

Professional Organizations

- Geological Society of America (2007 to present)
 - *SDSMT Campus Representative (2018 to present)*
 - *Rocky Mountain Section Chair-elect (2019-2020); Chair (2020-2021); Past-chair (2021-2022)*
- International Society for Environmental Biogeochemistry (2011 to present)
 - *Treasurer (Jan. 2020)*
- National Speleological Society (2011 to present)
 - *Vice Chair of the Biology Section (2017 to present)*
- Geochemical Society (2014 to present)
- Soil Science Society of America (2017 to present)

Professional Service

Manuscript Reviews (number of manuscripts reviewed)

- *Journal of Archaeological Science* (1)
- *Southeastern Naturalist* (1)
- *Minerals* (1)
- *Scientific Reports* (2)
- *American Mineralogist* (1)
- *Molecular Ecology* (1)
- *Geomicrobiology Journal* (1)
- *Spectroscopy Letters* (1)
- *PLoS One* (3)
- *Geochimica et Cosmochimica Acta* (1)
- *Paleogeography, Paleoclimatology, Paleoecology* (1)
- *Environmental Science and Pollution* (1)
- *Archaeological and Anthropological Sciences* (1)
- *Applied Microbiology and Biotechnology* (1)
- *Frontiers Ecology and Evolution* (1)
- *Chemical Geology* (1)

Grant Proposal Reviews

- May-June 2019: Cave Conservancy Foundation; Student research grants to support karst-related research across all disciplines. Reviewed 3 Master's and 11 Ph.D. proposals (\$7,000 for one MS, \$20,000 for one Ph.D. student).
- May 2018: Cave Conservancy Foundation; Reviewed 4 Master's and 12 Ph.D. proposals (\$7,000 for one MS, \$20,000 for one Ph.D. student).
- May 2017: Cave Conservancy Foundation; Reviewed 3 Master's and 12 Ph.D. proposals (\$7,000 for one MS, \$20,000 for one Ph.D. student).
- May 2016: Cave Conservancy Foundation; Reviewed 5 Master's and 8 Ph.D. grant proposals (\$5,000 for one MS, \$15,000 for one Ph.D. student).

Conference Session Organization

- July 2022: Part of the planning committee for the *National Speleological Society* (NSS) Convention to be held in Custer, SD. Additionally, planning and leading affiliated Geology Field Trip (1 day regional geology)
- July 2020: Chair of Biology Session at the NSS Convention, Elkins, WV with an affiliated poster session [cancelled due to COVID-19].
- June 2019: Chair of Biology Session at the NSS Convention, Cookeville, TN, with an affiliated poster session.
- July/August 2018: Chair of Biology Session at the NSS Convention, Helena, MT.
- April 2018: Southeastern GSA Section Meeting, Knoxville, TN
 - Chair of a Topical Session, "Biogeochemical cycling and microbial dynamics in response to pulsed events."
 - Lead and Organized a Field Trip titled, "Nutrient hotspots through time," with visits to the Late Neogene Gray Fossil Site (Gray, TN) and training at the Anthropological Research Facility (Knoxville, TN), a human decomposition facility
 - Co-chair of a Topical Session, "Linkages among subterranean ecosystems and geological events in the eastern US."
- June 2017: Chair of Biology Session at the NSS Convention, Rio Rancho, NM.
- July 2016: Chair of Biology Session at the NSS Convention, Ely, NV, with an affiliated poster session.
- July 2015: Chair of Biology Session at the NSS Convention, Waynesville, MO, with an affiliated poster session.

- October 2014: GSA Pardee Symposium Co-chair “Apatites I have known: from Man to Mars” *Geological Society of America*, Vancouver, Canada, with Larry Taylor (UTK). Also had an affiliated poster session of the same name.

Community Engagement

- Board Member, Vore Buffalo Jump Site, Sundance, Wyoming (Dec. 2018 to present)

Career Development and Professional Training

- 2020: Teaching Online 101; participated in SDSMT week-long workshop to develop online teaching skills
 - 2019: Participated in the Cutting Edge Workshop, Early Career Geoscience Faculty Workshop: Teaching, Research and Managing your Career, College Park, MD
 - 2018: Participated in NSF EPSCoR CAREER grant proposal workshop
 - 2017: Participated in Software Carpentry Workshop, focused on R, Unix, and git, Knoxville, TN
 - 2014-15: Certificate for Undergraduate Teaching Skills (CUTS) offered by Saint Louis University through the Reinert Center for Transformative Teaching and Learning
 - 2014: Participated in a bioinformatics workshop focusing on Galaxy, hosted by the UC Davis Genomics Institute, Davis, CA
 - 2013: Participated in the Cutting Edge Workshop, Preparing for a Career in Academic Geosciences, Boulder, CO
 - 2012: Participated in Microbe-Mineral Interactions Workshop, International Society for Environmental Biogeochemistry, Cancun, Mexico
 - 2010: Participated in a bioinformatics training course using *Mothur*, University of Michigan, Detroit, MI
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